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Indian Standard

INTERFERENCE TO MOBILE RADIOCOMMUNICATIONS IN THE PRESENCE OF IMPULSIVE NOISE — METHODS OF JUDGING DEGRADATION AND MEASURES TO IMPROVE PERFORMANCE

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Electromagnetic Compatibility Sectional Committee, LTD 22

NATIONAL FOREWORD

This Indian Standard which is identical with CISPR 21 (1999) 'Interference to mobile radiocommunications in the presence of impulsive noise — Methods of judging degradation and measures to improve performance' issued by the International Special Committee on Radio Interference (CISPR) was adopted by the Bureau of Indian Standards on the recommendations of the Electromagnetic Compatibility Sectional Committee and approval of the Electronics and Information Technology Division Council.

The text of the IEC Standard has been approved as suitable for publication as an Indian Standard without deviations. Certain conventions are, however, not identical to those used in Indian Standards. Attention is particularly drawn to the following:

a) Wherever the words 'International Standard' appear referring to this standard, they should be read as 'Indian Standard'.

b) Comma (,) has been used as a decimal marker while in Indian Standards, the current practice is to use a point (.) as the decimal marker.

In this adopted standard, reference appears to the following International Standard for which Indian Standard also exists. The corresponding Indian Standard which is to be substituted in its place is listed below along with its degree of equivalence for the edition indicated:

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
CISPR 12(1997) Vehicles, motorboats and spark-ignited engine-driven devices — Radio-disturbance characteristics — Limits and methods of measurement	IS 6873 (Part 1) : 1999 Limits and methods of measurement of radio disturbance characteristics: Part 1 Vehicles, motorboats and spark-ignited engine-driven devices (*second revision*)	Identical

The concernced Technical Committee responsible for the preparation of this standard has reviewed the provisions of the following International Standard and has decided that the same is acceptable for use in conjunction with this standard:

International Standard	*Title*
IEC 60489-3 (1988)	Methods of measurement for radio equipment used in the mobile services — Part 3 : Receivers for A3E or F3E emissions
ITU-R Recommendation BS.562-3 :1990	Subjective assessment of sound quality

Only the English language text in the International Standard has been retained while adopting it in this Indian Standard.

Indian Standard

INTERFERENCE TO MOBILE RADIOCOMMUNICATIONS IN THE PRESENCE OF IMPULSIVE NOISE — METHODS OF JUDGING DEGRADATION AND MEASURES TO IMPROVE PERFORMANCE

1 Scope

This standard provides methods of judging the degradation of radio communication in the presence of impulsive noise and recommends ways of improving radio performance.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 60489-3:1988, *Methods of measurement for radio equipment used in the mobile services – Part 3: Receivers for A3E or F3E emissions*

CISPR 12:1997, *Vehicles, motorboats and spark-ignited engine-driven devices – Radio disturbance characteristics – Limits and methods of measurement*

ITU-R Recommendation BS.562-3:1990, *Subjective assessment of sound quality*

3 Survey of methods of judging degradation to radio channel

Test programs have been conducted in the United States of America by the Federal Communications Commission (FCC) and the Motor Vehicle Manufacturers Association (MVMA, later the American Automobile Manufacturers Association, AAMA, now disbanded). These test programs were directed toward providing a better understanding of the effects of motor vehicles on mobile communications reception.

The tests measured the degradation to communications systems subjectively and objectively at numerous receiver frequencies using several classes of automotive ignition noise sources such as a traffic stream and a controlled matrix of vehicles. Correlation between various objective and subjective measures of degradation was studied using rating scales employed by the FCC and MVMA for grading communication quality.

3.1 Subjective tests

3.1.1 Subjective tests of annoyance

Subjective degradation tests were conducted by the FCC using a single vehicle and groups of vehicles simulating traffic patterns. The FCC proposed and used a subjective jury rating scale based upon annoyance which had been used traditionally to determine the effects of ambient noise on job performance, accident rate, and fatigue of personnel.

Grade	Interfering effect was
5	almost nil
4	noticeable
3	annoying
2	very annoying
1	so bad the presence of speech was barely discernible

This grade system is very nearly the same as that given in ITU-R Recommendation BS.562-3 which should be used for future work if annoyance testing is conducted.

Quality		Impairment	
5	excellent	5	imperceptible
4	good	4	perceptible, but not annoying
3	fair	3	slightly annoying
2	poor	2	annoying
1	bad	1	very annoying

Annoyance is a highly subjective psychological reaction. The degree of annoyance caused by audible noise has been found to be influenced by a large number of variable physical and psychological factors (including illness, fatigue, status of interpersonal relations, and family problems).

3.1.2 Subjective tests of intelligibility

3.1.2.1 General

Since land mobile communication systems are used primarily to transmit voice messages, the performance of such systems should be based primarily on the intelligibility of the received signal in the presence of ignition noise.

The most common procedure for determining the intelligibility of a voice channel is a subjective method involving trained speakers and listener jury panels that directly score the percentage of speech that is intelligible. These schemes have the merit of producing repeatable results. Unfortunately, subjective scoring methods are expensive and time-consuming. As a result, they are not widely used.

The subjective scale for intelligibility proposed by the MVMA is

Grade	Description
5	could understand the message extremely well
4	could understand the message fairly well
3	think I understood, but had to guess at some words
2	could barely discern the message
1	could not detect speech at all

3.1.2.2 Intelligibility test method

Beginning at 20 dB quieting with the vehicle ignition noise source off, the radiofrequency input level was reduced by 1 dB decrements and scored at each decrement by the jury until the jury reached Grade 1 (worst). Then the radiofrequency input level was increased by 1 dB increments until the 20 dB quieting level was again reached.

The radiofrequency input level was then increased by 3 dB increments until the jury rated the quality Grade 5 (best). The radiofrequency input level was then decreased by 3 dB decrements until the 20 dB quieting level was reached.

The entire process was repeated with the vehicle noise source in operation.

The results of the two tests (noise source off/noise source on) were then compared and the difference in radiofrequency level for a particular quality grade (in decibels) was reported as the subjective degradation.

3.2 Objective tests

3.2.1 General

Uncertainty in subjective measurements arises from ambiguity of the rating scale definition, and variability of juror judgement. The latter source of error is largely caused by psychological factors. Objective measurements should have uncertainties less than those obtained from subjective tests.

A study carried out by the Institute for Telecommunication Sciences [1] develops a method of obtaining an objective intelligibility measure giving good results for speech sent through both analogue and digital noise-corrupted communication channels. The distortion measure is obtained using Linear Predictive Coding (LPC), a mathematical technique widely known for its application to the analysis and synthesis of speech.

3.2.2 Objective test method

To develop an objective intelligibility measure for corrupted speech, a comparison must be performed between the distorted speech and the original noise-free speech. A subjective intelligibility measure of the distorted speech must also be available in order to judge the quality of the objective measure being used. Both of these requirements are met by first making a noise-free master tape of preselected speech, then sending it through the voice communication channels to be tested and making a recording of the speech at the channel outputs. The latter recording can be subjectively scored for intelligibility, and also compared with the original speech by a mathematical technique to obtain an objective score.

The preselected speech to be sent over a voice channel for intelligibility scoring consists of phonetically balanced groups of isolated words, as opposed to complete sentences or nonsense syllables. These phonetically balanced words were used because subjective scores have been shown to be repeatable, which is a necessary criterion for this study. (During tests employing vehicles as a noise source, subjective scoring by listener panels was conducted and compared to the objective scores, resulting in good correlation.)

The set of objective measurements of degradation included (1) the signal-to-noise and distortion (SINAD) sensitivity and (2) the 20 dB quieting sensitivity. The objective test procedures used in the MVMA tests complied with IEC 60489-3.

3.3 Conclusions relating to judgement of degradation

Numerous studies have been conducted over the years to develop a simple, inexpensive, objective method of measuring land mobile receiver degradation in the presence of ignition noise. Linear Predictive Coding (LPC) is neither simple nor inexpensive (when compared to the equipment used for CISPR 12 measurements) but it is technically a good objective method for measuring receiver degradation.

Subjective tests have proved to be effective in rating mobile receiver degradation. Of the two subjective rating methods in use, intelligibility was determined to be superior to annoyance in characterizing the effect of radio noise on a communication link. Most objective measurements taken during the subjective testing, however, showed poor correlation. The Linear Predictive Coding (LPC) method showed good correlation with the subjective intelligibility test method. Subjective tests are preferred, however, because of their reduced complexity and resulting lesser cost.

Considering only the subjective test methods, and as a result of the numerous tests conducted, it is recommended that intelligibility be used as the index of communications system performance rather than annoyance.

4 Improvement of performance of mobile radio communication

Worldwide efforts to measure and control ignition interference have been undertaken since the foundation of CISPR in 1934. This work has resulted in the creation of several standards which, taken together, limit radiation from most of the vehicles currently being produced. Extensive experience with millions of these vehicles in a broad range of world environments tends to show that reduction in the present limit is not required for the protection of FM, AM and television broadcast receivers used in buildings along the roadside.

Present-day land mobile communications systems, however, are subject to interference from a variety of sources. Traditionally, these systems have employed a classical white Gaussian noise model when noise performance was considered [2]. The major contributor in the mobile radio environment is, however, impulse noise. Elementary improvements in receiver design have been proposed to optimize performance under impulsive conditions. Most of the following suggestions have found application in military high-frequency equipment and have proved to enhance receiver performance, yet they have not been universally utilized in frequency modulated very high-frequency commercial mobile equipment.

There is room for improvement at nearly every stage of traditional frequency-modulated very high-frequency receiving sections.

a) Radiofrequency amplifiers and mixers have employed MOSFETS, which are subject to gain compression and high third-order distortion. The use of balanced, bipolar, current-feedback radiofrequency amplifiers and double-balanced high-level passive mixers provides the high dynamic range [3] and good third-order intercept points required for mobile use.

b) The use of phase-locked loop methods to generate high-frequency injection signals reduces distortion products caused by sideband noise in conventional crystal oscillators.

c) Weak signal performance can be improved by the use of discriminators which provide increased rejection of amplitude-modulated noise compared to the presently used quadrature detectors [4] [5] [6].

d) The performance of noise blankers can be improved by moving them from the intermediate frequency amplifier to the radiofrequency amplifier, thus eliminating the (pulse-stretching) effect of bandpass filters in the intermediate frequency amplifiers.

5 Conclusion

CISPR 12 is in use worldwide for the measurement and control of ignition noise. No such similar standards are available to standardize criteria for the design of receiver noise rejection, or for the measurement thereof. Development of receiver rejection standards should be a high-priority requirement in the overall study of degradation to communication channels.

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